

GPS Fault Slip Sensors in Earthquake Alert Systems

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GPS can be used in real-time for potentially important emergency response applications as well as many scientific research uses, although scientific uses typically do not require real-time results. Here, we present a new concept to include GPS fault slip sensors into earthquake early warning systems, as an augmentation to seismic inertial sensors. We have successfully tested this GPS fault slip sensor in a prototype deployment on the San Andreas fault as of 15 November 2002.

Of course, the potential for issuing a warning of imminent strong shaking was initially proposed by J. D. Cooper in 1968. The idea has been further developed more recently (e.g., Heaton, 1985; Ellsworth & Heaton, 1994), and seismic systems for this have now been demonstrated and implemented, for example, the Urgent Earthquake Detection and Alarm System (UEDAS) system in Japan (Nakamura & Tucker, 1988). Some limitations in the robustness and trustworthiness of the systems, as well as costs, may explain why these arrays are not more widespread. To our knowledge, before now, only seismic sensors have been previously considered in designing solutions to this problem. We will describe, and also show test results from, the first deployment of a GPS-based augmentation to earthquake alert systems. GPS can be used to detect surface slip on a fault in real-time. Thus, adding GPS can improve response time and robustness of the system, and can decrease the chance that a small event (without surface rupture) is somehow interpreted by the seismic sensors as being a large event.

Our system will robustly detect slip on a fault, in real-time, if slip exceeds a few centimeters. Where two SCIGN stations straddle the San Andreas fault near Gorman, the fault is not known to creep, so detected displacement would be a clear indication that a large event has begun. Slip at the ground surface would likely occur within seconds after a large event has begun, conceivably well before the seismic array data alone can yet be relied upon to assess whether the event is large or small. With this, and several other specific cases where we are deploying this instrumentation, we feel that GPS data acquired and processed in real-time can significantly add to earthquake alert systems. Along with real-time use of GPS for monitoring large engineered structures, the potential for providing earthquake information rapidly after future earthquakes, from a variety of real-time GPS systems, is considerable. The GPS slip sensor concept relies upon high sampling-rate data, acquired and processed in real-time. Preferably, the data would be from a braced array that is located close to, and spanning, the main strands of an active fault. Such arrays are not likely to be included in projects that are intended to study longer wavelength formation of the crust, so may require special 'zipper' deployments along hazardous active faults. Observations from such near-field GPS and broad-band seismic sensor arrays, associated with future large earthquakes, could well provide unique and vital information for gaining insight into aspects of the rupture process and earthquake source physics in general.

Ellsworth, William L., and Thomas H. Heaton (April, 1994) Real-Time Analysis of Earthquakes: Early Warning Systems and Rapid Damage Assessment, Sensors.
Heaton, T. H. (1985) A Model for a Seismic Computerized Alert Network, Science 228, 987-990.
Nakamura, Y., and B. E. Tucker (1988) Japan's Earthquake Warning System: Should it Be Imported To California?, California Geology, pp. 33-40.

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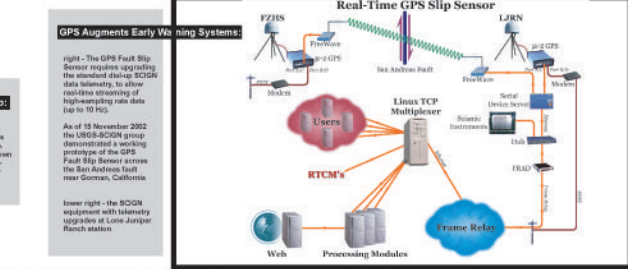
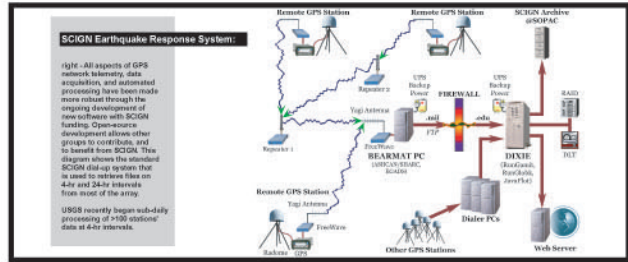
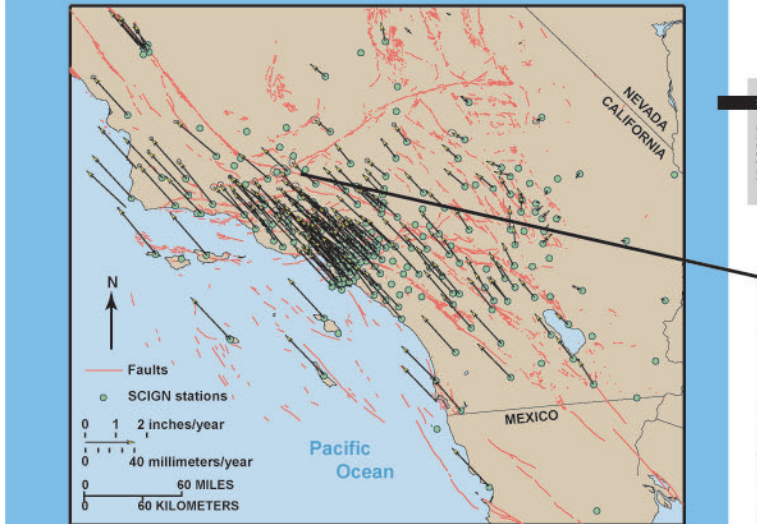




Sentinel Over Los Angeles
upper left - 'Packard' station, also the Dyeran Park Blvd thrust fault
Photograph by John Goff, USGS

Global Positioning System (GPS) satellite

SCIGN
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INTEGRATED GPS NETWORK



Spanning the San Andreas
left - Lone Jumper Ranch station, on the North American side of the San Andreas fault, with view across to Pacific Park High School also on the Pacific side.
Photograph by Howard Moberly